

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images,
Please do not report the images to the
Image Problem Mailbox.

(19)日本国特許庁(JP)

(12) 公開特許公報(A)

(11)特許出願公開番号

特開平5-41541

(43)公開日 平成5年(1993)2月19日

(51)IntCl. ³	識別記号	庁内整理番号	FI	技術表示箇所
H 0 1 L 33/00	C	8934-4M		
21/205		7454-4M		
27/12		8728-4M		

審査請求 未請求 請求項の数3(全 6 頁)

(21)出願番号 特願平3-219179

(22)出願日 平成3年(1991)8月5日

(71)出願人 000004226

日本電信電話株式会社

東京都千代田区内幸町一丁目1番6号

(72)発明者 佐々木 徹

東京都千代田区内幸町一丁目1番6号 日

本電信電話株式会社内

(72)発明者 松岡 隆志

東京都千代田区内幸町一丁目1番6号 日

本電信電話株式会社内

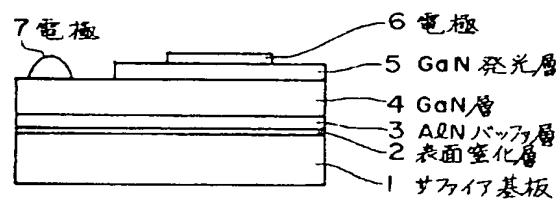
(74)代理人 弁理士 高山 敏夫 (外1名)

(54)【発明の名称】 半導体発光素子及びその作製方法

(57)【要約】

【目的】 III族窒化物半導体InGaAlNエピタキシャル膜の高品質化による高効率・長寿命の半導体発光素子を提供すること。

【構成】 サファイア基板1上に、表面窒化層2を形成し、この上にAlNバッファ層3、ついでGaN層4を形成し、ついでGaN発光層5を形成した半導体発光素子及びその作製方法である。



【特許請求の範囲】

【請求項 1】 サファイア基板上に形成された $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) を少なくとも 1 層含む半導体発光素子において、前記サファイア基板表面に形成された窒化層と前記窒化層上に堆積された AlN バッファ層とを含むことを特徴とする半導体発光素子。

【請求項 2】 サファイア基板を窒素原料ガス雰囲気中で熱処理し、基板表面を単結晶 AlN 化する第 1 の工程と、窒化層上にアルミニウム原料ガスとの反応により多結晶もしくはアモルファス AlN バッファ層を堆積する第 2 の工程と、前記 AlN バッファ層をその堆積温度よりも高温でアニールする第 3 の工程と、 InGaAlN 層を少なくとも 1 層含む発光層を形成する第 4 の工程とを含むことを特徴とする半導体発光素子の作製方法。

【請求項 3】 アルミニウム原料ガスとして有機アルミニウム、ハロゲン化アルミニウムあるいは金属アルミニウム蒸気のいずれか 1 つ、窒素原料ガスとしては N_2H_4 、 N_2H_2 あるいは有機アミンのいずれか 1 つから選ばれることを特徴とする請求項 2 記載の半導体発光素子の作製方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 本発明は、可視（赤外）から紫外で発光する半導体発光素子及びその作製方法に関する。

【0002】

【従来の技術】 III 族窒化物半導体 InN 、 GaN 、 AlN 、 InGaAlN では大型のバルク単結晶が成長できないため、従来サファイアを基板として用いたエピタキシャル成長が一般に行われてきた。しかし、サファイアと上記 III 族窒化物半導体の間には $11 \sim 23\%$ の格子不整合および $\sim 2 \times 10^{-6}$ [d.o.g.] の熱膨張係数差が存在し、このために生じる不整合転位及び熱歪みが III 族窒化物半導体エピタキシャル膜の結晶性・電気的光学的特性の向上の妨げとなっている。また、両者の化学的性質の違いにより生じる界面エネルギーのため、サファイア上に直接成長した III 族窒化物半導体エピタキシャル膜は顕著な三次元成長を起こし、表面形態の平坦化・結晶性の向上が難しい。この結果、サファイア基板上に作製した $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) 発光素子は発光効率や素子寿命を十分に向上できないという問題があった。

【0003】 格子不整合の大きなヘテロエピタキシャル成長では、基板・エピタキシャル膜の中間的な物理定数をもつ材料を介して成長を行うことによりエピタキシャル膜の品質を向上することができる。サファイア上の III 族窒化物半導体成長では AlN 層を介した成長が有効である。これは AlN がサファイアと III 族窒化物半導体の中間的な格子定数と熱膨張係数をもつため、格子不整合と熱歪みが効率的に緩和される結果である。ま

た、 AlN と III 族窒化物半導体は化学的性質が近く、両者の間の界面エネルギーも小さい。このため、平坦な AlN 層を形成できさえすればその上に成長するエピタキシャル膜の三次元成長を抑制できる。

【0004】 従来、以上の目的の AlN 形成方法としては、① サファイア基板を NH_3 、 N_2H_2 、あるいは有機アミン等の窒素原料ガス雰囲気中で熱処理することにより基板表面を単結晶 AlN 化する方法、② AlN の単結晶成長が可能な高温に保ったサファイア基板上に有機アルミニウム、ハロゲン化アルミニウムあるいは金属アルミニウム蒸気等のアルミニウム原料ガスと窒素原料ガスを供給し単結晶 AlN 層を堆積する方法、③ $500 \sim 1000^\circ\text{C}$ の低温でアルミニウム原料ガスと窒素原料ガスを供給し、数 $100 \sim 1000 \text{ \AA}$ の多結晶もしくはアモルファス AlN 層を堆積した後、これより高温でアニールすることにより単結晶化する方法があった。

【0005】 ①の方法では、数 10 \AA の窒化層を再現性良く形成できる上、この単結晶 AlN 層は傾斜的な組成変化を伴うためわずかな数 10 \AA の領域で効果的に格子不整合を緩和する。しかしながら詳細な観察の結果、この方法で作製した AlN 層は 10 \AA のオーダーで表面荒れを起こしていることが明らかになった。このことに起因して、①の方法で作製した AlN 層上にエピタキシャル成長を行うと、膜厚の増加に伴いこの凹凸が強調され平坦な表面形状が得られない。

【0006】 また、②の方法で作製した AlN 層は高温で膜成長を行うため、三次元成長核の形成が避けられない。以上のことより、①及び②の方法で作製した AlN バッファ層は、その上に成長したエピタキシャル膜の電気的光学的特性の向上には効果を有するものの、三次元成長の抑制には無力である。

【0007】 ③の方法は、三次元成長が起こらないような低温で AlN 膜を堆積するため平坦なバッファ層の形成が可能となる。この結果、その上に成長するエピタキシャル膜の三次元成長が抑制され、表面形態の平坦化・結晶性の向上を達成できる。ところで、サファイア上に低温堆積した AlN 層にはアニールによって単結晶化するための最大膜厚 d_{max} と、連続膜となるために必要な最低膜厚 d_{min} が存在し、膜厚を d_{max} と d_{min} 間に制御する必要がある。通常、 d_{max} は 1000 \AA 程度、 d_{min} は $100 \sim 200 \text{ \AA}$ である。さらに、 AlN バッファ層厚がこの範囲であっても、エピタキシャル膜の特性は AlN バッファ層厚に強く依存する。しかしながら、サファイア基板上に直接 AlN 層を堆積する従来の方法では、膜厚の制御性が悪いという問題があった。この原因を把握するため、成長初期段階におけるサファイア上 AlN の成長膜厚の成長時間依存性を詳細に調べた結果、図 5 に示すような再現性のない $1 \sim 3$ 分の時間遅れが存在することが明らかになった。この時間遅れはサファイアと AlN の化学的性質の差に起因し、基板上にお

けるアルミニウム原料ガスの濃度がある濃度に達するまで堆積が開始しないことが原因である。これはサファイア上に直接AlNを堆積しようとする限り本質的な問題である。

【0008】

【発明が解決しようとする課題】本発明は上記の問題点を解決するためなされたもので、その目的は、III族窒化物半導体 $In_{1-x-y}Ga_xAl_yN$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$)エピタキシャル膜の高品質化による高効率・長寿命の半導体発光素子を提供すること、及び発光素子を再現性よく作製する方法を提供することにある。

【0009】

【課題を解決するための手段】上記の目的を達成するため、本発明はサファイア基板上に形成された $In_{1-x-y}Ga_xAl_yN$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$)を少なくとも1層含む半導体発光素子において、前記サファイア基板表面に形成された窒化層と前記窒化層上に堆積されたAlNバッファ層とを含むことを特徴とする半導体発光素子を発明の要旨とするものである。さらに、本発明はサファイア基板を窒素原料ガス雰囲気中で熱処理し、基板表面を単結晶AlN化する第1の工程と、窒化層上にアルミニウム原料ガスとの反応により多結晶もしくはアモルファスAlNバッファ層を堆積する第2の工程と、前記AlNバッファ層をその堆積温度よりも高温でアニールする第3の工程と、 $InGaAlN$ 層を少なくとも1層含む発光層を形成する第4の工程とを含むことを特徴とする半導体発光素子の作製方法を発明の要旨とするものである。換言すれば、本発明の半導体発光素子は、サファイア基板表面に形成した窒化層と該窒化層上に堆積したAlNバッファ層を含むことを最も主要な特徴とする。また、本発明の半導体発光素子の作製方法は、サファイア基板を窒素原料ガス雰囲気中で窒化処理する第一の工程と、該窒化層上にアルミニウム原料ガスと窒素原料ガスとの反応によりAlNバッファ層を堆積する第二の工程と、該AlNバッファ層を堆積温度よりも高温でアニールする第三の工程を含むことを最も主要な特徴とする。

【0010】従来のAlN層を介してサファイア上に作製した半導体発光素子とはその構造及び作製方法において以下の点が異なる。すなわち、窒化処理により表面を単結晶AlN化したサファイア基板上に作製した半導体発光素子とは、表面窒化層に接して低温堆積後アニールにより単結晶化したAlNバッファ層を含む点異なる。サファイア基板上にAlNの単結晶成長温度以上の高温で堆積したAlNバッファ層を介して作製した半導体発光素子とは、AlNバッファ層をサファイア表面窒化層を介して堆積している点及びAlN層の堆積を平坦なAlN層が得られる低温で行いその後これより高温でアニールすることにより単結晶化する点異なる。ま

た、低温堆積した後これより高温でアニールすることにより単結晶化したAlNバッファ層を介して作製した半導体発光素子とは、AlNバッファ層をサファイア表面窒化層を介して堆積している点異なる。

【0011】

【作用】本発明においては、サファイア基板上に、単結晶化したAlNバッファ層が形成されているため、成長初期の時間遅れを生ずることなく、成長を開始することができ、さらに平坦性に優れている作用を有する。

【0012】

【実施例】次に本発明の実施例について説明する。なお、実施例は一つの例示であって、本発明の精神を逸脱しない範囲で、種々の変更あるいは改良を行い得ることは言うまでもない。

【0013】（実施例1）図1は本発明の第一の実施例を説明する図であって、発光素子の断面を示す。本発光素子はサファイア（0001）基板1の表面に形成した窒化層2（窒化深さ50Å）、膜厚500ÅのAlNバッファ層3、膜厚5μmのSiドープn型低抵抗GaN層4、膜厚0.5μmのZnドピングにより半絶縁化したGaN発光層5、半絶縁層の電極6、n型低抵抗層のオーミック電極7からなる。電極6に正の電圧を電極7に負の電圧を加えると発光層5は480nmの波長で発光した。最大光出力は0.8mWであり、外部量子効率率は0.2%であった。本実施例では、n型低抵抗層、半絶縁層としてGaNを用いたが、これに代えて $In_{1-x-y}Ga_xAl_yN$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$)を用いることにより発光波長を300~800nmの範囲で変化させることができる。

【0014】（実施例2）図2は本発明の第二の実施例を説明する図であって、発光素子の断面を示す。本発光素子はサファイア（0001）基板10の表面に形成した窒化層11（窒化深さ50Å）、膜厚500ÅのAlNバッファ層12、膜厚5μmのSiドープn型InAlNクラッド層13、膜厚0.5μmのアンダーインGaN活性層14、膜厚2μmのMgドープp型InAlNクラッド層15、p型クラッド層のオーミック電極16、n型クラッド層のオーミック電極17からなる。ここに示したInAlN層13及びInGaN層14は、互いに格子整合し、クラッド層のバンドギャップエネルギーが活性層のバンドギャップエネルギーに比べ0.3eV以上大きくなるように組成を選んだ。この結果、クラッド層の屈折率は活性層の屈折率に比べ約10%小さくなる。電極16に正の電圧を電極17に負の電圧を加えると活性層14は420nmの波長で発光した。最大光出力は13mWであり、外部量子効率率は3%であった。

【0015】この実施例では、n型及びp型クラッド層としてInAlNを、また活性層としてInGaNを用いたが、互いに格子整合し、クラッド層のバンドギャッ

ブエネルギーが活性層のバンドギャップエネルギーに比べ0.3 eV以上大きくなるという条件の下で組成を変化させることにより、発光波長を190~650 nmの範囲で変化させることができる。

【0016】図3は、原料ガスとしてIII族有機金属とNH₃を用いる場合について、本発明の半導体発光素子の作製方法を実施するための成長装置の一例を示すものである。図において、20はサファイア(0001)基板、21はカーボン・サセプタ、22は石英反応管、23は高周波誘導コイル、24は熱電対、25は有機金属ガス導入管、26はNH₃ガス導入管、27はH₂ガス及びN₂ガス導入管、28は排気口を示す。

【0017】この装置で、本発明の半導体発光素子用の多層膜構造を作製するには、まず石英反応管22内を真空排気装置により排気する。次に、石英反応管22内に0.5~20 l/分のH₂ガスを導入した後、高周波誘導コイル23を通電することによりカーボン・サセプタ21を1000~1300℃に加熱し1~60分保持することにより、サファイア(0001)基板20表面を清浄化する。続いて、H₂ガスを0.5~20 l/分のNH₃ガスに切り替え1~60分保持することにより、サファイア(0001)基板20表面を単結晶AlN化する。次に、カーボン・サセプタ21の温度を500~1000℃まで降温する。この状態で、バブラの温度を15~60℃に設定したトリメチルアルミニウム(TMAI)を1~1000 cc/分のH₂ガス(あるいはN₂もしくはArガス)でバブリングし、0~20 l/分のH₂ガス(あるいはN₂もしくはArガス)と合流させた後導入管25より石英反応管22へ供給し単結晶もしくはアモルファスのAlN層を堆積する。成長中の石英反応管22内の総ガス圧は40~1000 Torrに調整する。AlNを10~2000 Å堆積させたところでTMAIの石英反応管22への供給を止め、カーボン・サセプタ21を1000~1300℃に加熱しNH₃雰囲気中で1~60分保持することにより堆積したAlN膜を単結晶化する。これに続けて、発光素子用のクラッド層、活性層等の多層膜構造を作製する。

【0018】上記の実施例では、III族原料及び空素原料としてTMAI及びNH₃を用いたが、これに代えてTEAI等の他のIII族有機金属あるいはIII族ハライド化物等の他のIII族原料及びN₂、H₂や有機アミン等のその他の空素原料を用いても同様の効果が得られる。上記の実施例では、サファイア基板の面方位として(0001)面を用いたが、これに代えて(0112)面、(0110)面、(2110)面を用いても同様の効果が得られる。

【0019】

【発明の効果】本発明の半導体発光素子では予め空化処理することによってAlN化したサファイア表面にAlN層を低温堆積するため、図4の示すとおり成長初期の

時間遅れを生ずることなく成長を開始できる。このため、AlNバッファ層の膜厚制御を精密に再現性よく行うことができる。これはAlNの堆積に先立ってサファイア表面をAlN化させておいたため、アルミニウム原料ガスの基板表面への到達と同時に堆積が開始するためである。また、表面空化層上にAlNを堆積する場合には、未処理のサファイア基板に直接堆積する場合に比べより薄い膜厚で連続膜となる上、平坦性にも優れるという利点をもつ。さらに、サファイア基板上に形成した空化層はその上に堆積したAlNバッファ層の結晶性を向上させる効果を有するため、その上に成長したエピタキシャル膜の特性をも向上させる。また、低温堆積したAlN層は空化処理によりサファイア表面に生じた原子オーダーの凹凸を平坦化する作用を有するため、サファイア表面空化層上に直接III族空化物半導体薄膜をエピタキシャル成長する際に問題となる三次元成長を抑制することができる。

【0020】この結果、本発明によれば高効率・長寿命の半導体発光素子を再現性よく作製することができる。特に、サファイア基板上に形成した空化層がその上に堆積するAlN層の初期段階における膜厚制御性及びその平坦性及び結晶性を向上させることは、全く新規の効果である。

【図面の簡単な説明】

【図1】本発明の半導体発光素子の一実施例。

【図2】本発明の半導体発光素子の他の実施例。

【図3】本発明の半導体発光素子を作製する際に用いた化合物半導体薄膜のエピタキシャル成長装置。

【図4】空化処理したサファイア基板上でのAlN成長初期段階における成長膜厚の成長時間依存性を示す。

【図5】未処理サファイア基板上でのAlN成長初期段階における成長膜厚の成長時間依存性を示す。

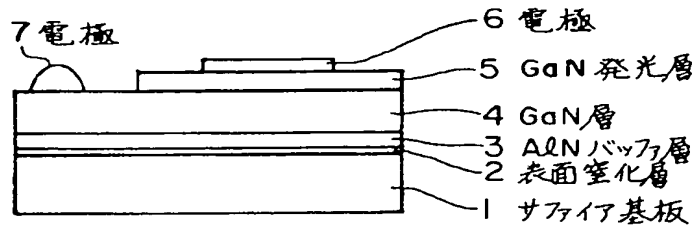
【符号の説明】

- 1 サファイア(0001)基板
- 2 サファイア表面空化層
- 3 AlNバッファ層
- 4 Siドープn型低抵抗GaN層
- 5 Znドープ半絶縁GaN発光層
- 6 半絶縁層の電極
- 7 n型低抵抗層のオーミック電極
- 10 サファイア(0001)基板
- 11 サファイア表面空化層
- 12 AlNバッファ層
- 13 Siドープn型InAlNクラッド層
- 14 アンドープInGaN活性層
- 15 Mgドープp型InAlNクラッド層
- 16 p型クラッド層のオーミック電極
- 17 n型クラッド層のオーミック電極
- 20 サファイア(0001)基板
- 21 カーボン・サセプタ

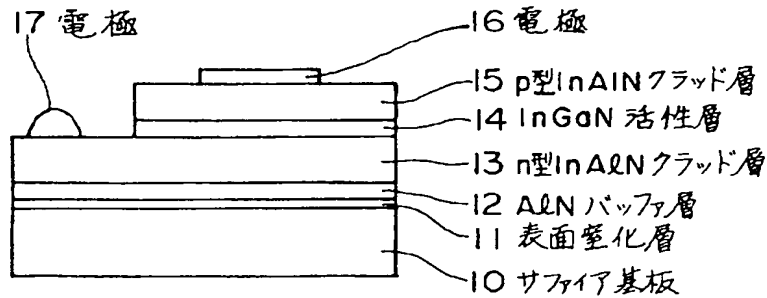
- 22 石英反応管
23 高周波誘導コイル
24 熱電対
25 有機金属ガス導入管

- 26 NH_3 ガス導入管
27 H_2 ガス及び N_2 ガス導入管
28 排気口

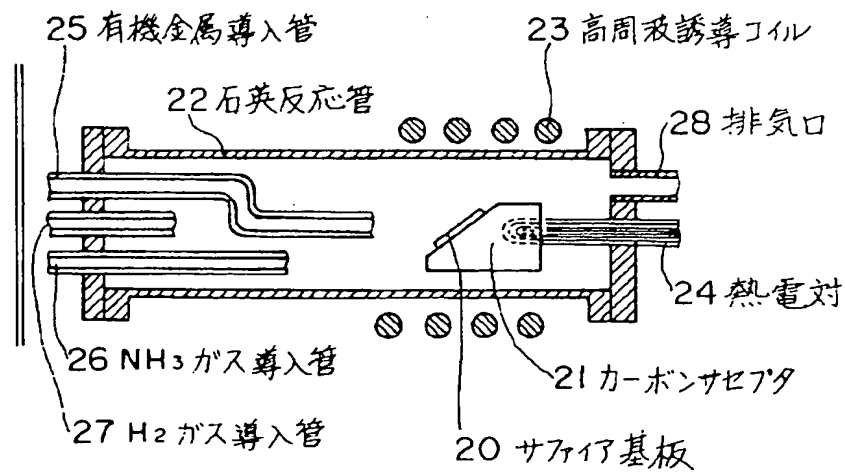
【図1】



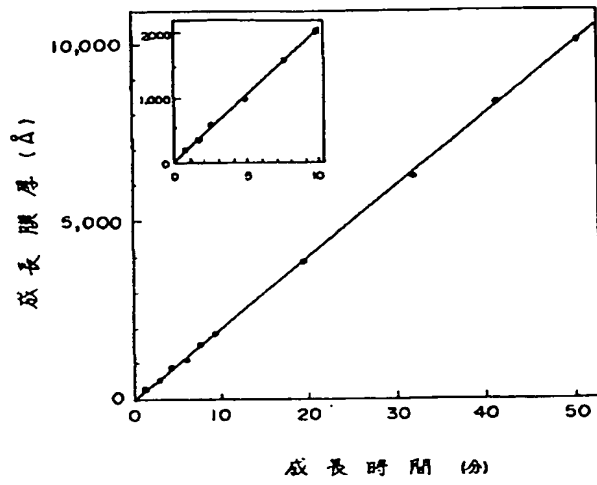
【図2】



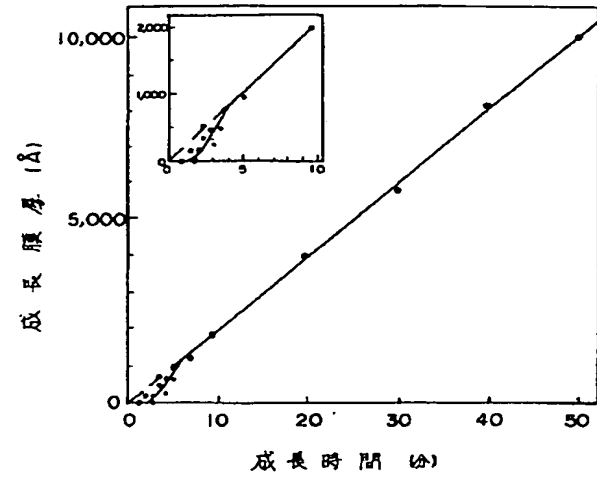
【図3】



【図 4】



【図 5】



PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-041541

(43)Date of publication of application : 19.02.1993

(51)Int.Cl.

H01L 33/00
H01L 21/205
H01L 27/12

(21)Application number : 03-219179

(71)Applicant : NIPPON TELEGR & TELEPH CORP
<NTT>

(22)Date of filing : 05.08.1991

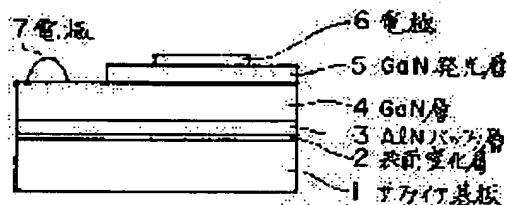
(72)Inventor : SASAKI TORU
MATSUOKA TAKASHI

(54) SEMICONDUCTOR LIGHT EMITTING DEVICE AND PREPARATION THEREOF

(57)Abstract:

PURPOSE: To provide a highly efficient and long-life semiconductor light emitting device produced by a higher quality of III group nitrided semiconductor InGaAlN epitaxial film.

CONSTITUTION: There is formed a surface nitrided layer 2 on a sapphire substrate 1. There are further formed an AlN buffer layer 3, a GaN layer 4 and a GaN light emitting layer 5 on the surface of the nitride layer, which constitutes the production method of a semiconductor light emitting device.



LEGAL STATUS

[Date of request for examination] 19.02.1998

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3147316

[Date of registration] 12.01.2001

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Copyright (C); 1998,2000 Japan Patent Office

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] The semiconductor light emitting device characterized by including the nitrated case formed in the aforementioned silicon-on-sapphire front face, and the AlN buffer layer deposited on the aforementioned nitrated case in the semiconductor light emitting device containing at least one layer ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) of $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ formed on silicon on sapphire.

[Claim 2] The production method of the semiconductor light emitting device characterized by providing the following. The 1st process which heat-treats silicon on sapphire in nitrogen material gas atmosphere, and forms a substrate front face into single crystal AlN. The 2nd process which deposits polycrystal or an amorphous AlN buffer layer by the reaction with aluminum material gas on a nitrated case. The 3rd process which anneals the aforementioned AlN buffer layer at an elevated temperature rather than the deposition temperature. The 4th process which forms the luminous layer containing at least one layer of InGaAlN layers.

[Claim 3] As any one of organic aluminum, an aluminum halide, or the metal aluminum steams, and nitrogen material gas, it is NH_3 and N_2H_2 as aluminum material gas. Or the production method of the semiconductor light emitting device according to claim 2 characterized by being chosen out of any one of the organic amines.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

 PRIOR ART

[Description of the Prior Art] In the III group nitride semiconductors InN, GaN, and AlN and InGaAlN, since a large-sized bulk single crystal cannot grow, generally epitaxial growth using sapphire as a substrate has been performed conventionally. However, between sapphire and the above-mentioned III group nitride semiconductor, the coefficient-of-thermal-expansion difference of grid mismatching [11 - 23% of] and -2×10^{-6} [dog-1] exists, and the mismatching transposition and heat distortion which are produced for this reason serve as hindrance of improvement in the crystallinity and the electric optical property of an III group nitride semiconductor epitaxial film. Moreover, because of the surface energy produced by the difference in both chemical property, the III group nitride semiconductor epitaxial film which grew directly causes remarkable three-dimensions growth on sapphire, and flattening of a surface gestalt and crystalline improvement are difficult for it to it. Consequently, the $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) light emitting device produced on silicon on sapphire had the problem that neither luminous efficiency nor an element life could fully be improved.

[0003] In big hetero-epitaxial growth of grid mismatching, the quality of an epitaxial film can be improved by growing up through material with the middle-physical constant of a substrate and an epitaxial film. The growth which minded the AlN layer in the III group nitride semiconductor growth on sapphire is effective. This is the result of easing grid mismatching and heat distortion efficiently, since AlN has middle-the lattice constant and coefficient of thermal expansion of sapphire and an III group nitride semiconductor. Moreover, the surface energy between near and both also has [AlN and an III group nitride semiconductor] small chemical property. For this reason, if only it can form a flat AlN layer, three-dimensions growth of the epitaxial film which grows on it can be suppressed.

[0004] As the AlN formation method of the above purpose, conventionally ** How to form a substrate front face into single crystal AlN by heat-treating silicon on sapphire in nitrogen material gas atmosphere, such as NH_3 , N_2 , H_2 , or an organic amine ** How to supply aluminum material gas and nitrogen material gas, such as organic aluminum, an aluminum halide, or a metal aluminum steam, and deposit a single crystal AlN layer on the silicon on sapphire maintained at the elevated temperature in which single crystal growth of AlN is possible ** After supplying aluminum material gas and nitrogen material gas at 500-1000-degree C low temperature and depositing several 100-1000Å polycrystal or an amorphous AlN layer, there was the method of single-crystal-izing by annealing at an elevated temperature from this.

[0005] ** when several 10Å nitrated case can be formed with sufficient repeatability, in order to accompany this single crystal AlN layer by inclination composition change by the method -- only -- ease grid mismatching effectively in several 10Å field However, it became clear that the AlN layer produced by this method has started the surface dry area to 10Å order as a result of detailed observation. It originates in this, and if it grows epitaxially on the AlN layer produced by the method of **, this irregularity will be emphasized with the increase in thickness, and the shape of flat surface type will not be acquired.

[0006] Moreover, in order that the AlN layer produced by the method of ** may perform film growth at an elevated temperature, formation of a three-dimensions growth nucleus is not avoided. Although the AlN buffer layer produced by the method of ** and ** has an effect in improvement in the electric optical property of the epitaxial film which grew on it, it is more powerless than the above thing to suppression of three-dimensions growth.

[0007] ** Since a method deposits an AlN film at low temperature from which three-dimensions growth does not take place, the formation of a flat buffer layer of it is attained. Consequently, three-dimensions growth of the epitaxial film which grows on it is suppressed, and flattening of a surface gestalt and crystalline improvement can be attained. By the way, the maximum thickness d_{max} for single-crystal-izing by annealing in the AlN layer which carried out low-temperature deposition on sapphire The minimum thickness d_{min} required since it becomes a continuation film It exists and is d_{max} about thickness. d_{min} It is necessary to control in between. Usually, d_{max} About 1000Å and d_{min} It is 100-200Å. Furthermore, even if AlN buffer thickness is this range, it depends for the property of an epitaxial film to AlN buffer thickness strongly. However, there was a problem that the controllability of thickness was bad, by the conventional method of depositing a direct AlN layer on silicon on sapphire. In order to grasp this cause, as a result of investigating the growth time dependency of the growth thickness on [AlN] sapphire in a growth initial stage in detail, it became clear that the time lag for 1 - 3 minutes without repeatability as shown in drawing 5 exists. It is because deposition does not begin until it reaches the concentration which this time lag originates in the difference of the chemical property of sapphire and AlN, and has the concentration of the aluminum material gas on a substrate. This is an essential problem as long as it is going to deposit AlN directly on sapphire.

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to the semiconductor light emitting device which is ultraviolet and emits light from it being visible (infrared), and its production method.

[0002]

[Description of the Prior Art] In the III group nitride semiconductors InN, GaN, and AlN and InGaAlN, since a large-sized bulk single crystal cannot grow, generally epitaxial growth using sapphire as a substrate has been performed conventionally. However, between sapphire and the above-mentioned III group nitride semiconductor, the coefficient-of-thermal-expansion difference of grid mismatching [11 - 23% of] and -2×10^{-6} [dog-1] exists, and the mismatching transposition and heat distortion which are produced for this reason serve as hindrance of improvement in the crystallinity and the electric optical property of an III group nitride semiconductor epitaxial film. Moreover, because of the surface energy produced by the difference in both chemical property, the III group nitride semiconductor epitaxial film which grew directly causes remarkable three-dimensions growth on sapphire, and flattening of a surface gestalt and crystalline improvement are difficult for it to it. Consequently, the In_{1-x-y}Ga_xAl_yN ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) light emitting device produced on silicon on sapphire had the problem that neither luminous efficiency nor an element life could fully be improved.

[0003] In big hetero-epitaxial growth of grid mismatching, the quality of an epitaxial film can be improved by growing up through material with the middle-physical constant of a substrate and an epitaxial film. The growth which minded the AlN layer in the III group nitride semiconductor growth on sapphire is effective. This is the result of easing grid mismatching and heat distortion efficiently, since AlN has middle-the lattice constant and coefficient of thermal expansion of sapphire and an III group nitride semiconductor. Moreover, the surface energy between near and both also has [AlN and an III group nitride semiconductor] small chemical property. For this reason, if only it can form a flat AlN layer, three-dimensions growth of the epitaxial film which grows on it can be suppressed.

[0004] As the AlN formation method of the above purpose, conventionally ** How to form a substrate front face into single crystal AlN by heat-treating silicon on sapphire in nitrogen material gas atmosphere, such as NH₃, N₂ H₂, or an organic amine ** How to supply aluminum material gas and nitrogen material gas, such as organic aluminum, an aluminum halide, or a metal aluminum steam, and deposit a single crystal AlN layer on the silicon on sapphire maintained at the elevated temperature in which single crystal growth of AlN is possible ** After supplying aluminum material gas and nitrogen material gas at 500-1000-degree C low temperature and depositing several 100-1000Å polycrystal or an amorphous AlN layer, there was the method of single-crystal-izing by annealing at an elevated temperature from this.

[0005] ** when several 10Å nitrated case can be formed with sufficient repeatability, in order to accompany this single crystal AlN layer by inclination composition change by the method -- only -- ease grid mismatching effectively in several 10Å field However, it became clear that the AlN layer produced by this method has started the surface dry area to 10Å order as a result of detailed observation. It originates in this, and if it grows epitaxially on the AlN layer produced by the method of **, this irregularity will be emphasized with the increase in thickness, and the shape of flat surface type will not be acquired.

[0006] Moreover, in order that the AlN layer produced by the method of ** may perform film growth at an elevated temperature, formation of a three-dimensions growth nucleus is not avoided. Although the AlN buffer layer produced by the method of ** and ** has an effect in improvement in the electric optical property of the epitaxial film which grew on it, it is more powerless than the above thing to suppression of three-dimensions growth.

[0007] ** Since a method deposits an AlN film at low temperature from which three-dimensions growth does not take place, the formation of a flat buffer layer of it is attained. Consequently, three-dimensions growth of the epitaxial film which grows on it is suppressed, and flattening of a surface gestalt and crystalline improvement can be attained. By the way, the maximum thickness d_{max} for single-crystal-izing by annealing in the AlN layer which carried out low-temperature deposition on sapphire The minimum thickness d_{min} required since it becomes a continuation film It exists and is d_{max} about thickness. d_{min} It is necessary to control in between. Usually, d_{max} About 1000Å and d_{min} It is 100-200Å. Furthermore, even if AlN buffer thickness is this range, it depends for the property of an epitaxial film to AlN buffer thickness strongly. However, there was a problem that the controllability of thickness was bad, by the conventional method of depositing a direct AlN layer on silicon on sapphire. In order to grasp this cause, as a result of investigating the growth time dependency of the growth thickness on [AlN] sapphire in a growth initial stage in detail, it became clear that the time lag for 1 - 3 minutes without repeatability as shown in drawing 5 exists.

It is because deposition does not begin until it reaches the concentration which this time lag originates in the difference of the chemical property of sapphire and AlN, and has the concentration of the aluminum material gas on a substrate. This is an essential problem as long as it is going to deposit AlN directly on sapphire.

[0008]

[Problem(s) to be Solved by the Invention] It was made in order that this invention might solve the above-mentioned trouble, and the purpose is in offering the efficient and long lasting semiconductor light emitting device by quality improvement of an III group nitride semiconductor $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) epitaxial film, and offering the method of producing a light emitting device with sufficient repeatability.

[0009]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, let this invention be the summary of invention of the semiconductor light emitting device characterized by including the nitrated case formed in the aforementioned silicon-on-sapphire front face, and the AlN buffer layer deposited on the aforementioned nitrated case in the semiconductor light emitting device containing at least one layer ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) of $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ formed on silicon on sapphire. Furthermore, the 1st process which this invention heat-treats silicon on sapphire in nitrogen material gas atmosphere, and forms a substrate front face into single crystal AlN, The 2nd process which deposits polycrystal or an amorphous AlN buffer layer by the reaction with aluminum material gas on a nitrated case, It considers as the summary of invention of the production method of the semiconductor light emitting device characterized by including the 3rd process which anneals the aforementioned AlN buffer layer at an elevated temperature rather than the deposition temperature, and the 4th process which forms the luminous layer containing at least one layer of InGaAlN layers. If it puts in another way, the semiconductor light emitting device of this invention will be characterized [main] by including the AlN buffer layer deposited on the nitrated case formed in the silicon-on-sapphire front face, and this nitrated case. Moreover, the production method of the semiconductor light emitting device of this invention is characterized [main] by including the first process which carries out nitriding treatment of the silicon on sapphire in nitrogen material gas atmosphere, the second process which deposits an AlN buffer layer by the reaction of aluminum material gas and nitrogen material gas on this nitrated case, and the third process which anneals this AlN buffer layer at an elevated temperature rather than deposition temperature.

[0010] In the structure and the production method, the following points differ from the semiconductor light emitting device produced on sapphire through the conventional AlN layer. That is, the points containing the AlN buffer layer single-crystal-ized by annealing after low-temperature deposition in contact with the semiconductor light emitting device which produced the front face by nitriding treatment on the silicon on sapphire which turned single crystal AlN to the surface nitrated case differ. The single-crystal-ized point differs from the semiconductor light emitting device produced through the AlN buffer layer deposited at the elevated temperature more than the single crystal growth temperature of AlN on silicon on sapphire by performing deposition of the point which has deposited the AlN buffer layer through a sapphire surface nitrated case, and an AlN layer at the low temperature from which a flat AlN layer is obtained, and annealing at an elevated temperature from this after that. Moreover, the point which has deposited the AlN buffer layer through a sapphire surface nitrated case differs from the semiconductor light emitting device produced through the AlN buffer layer single-crystal-ized by annealing at an elevated temperature from this after carrying out low-temperature deposition.

[0011]

[Function] In this invention, without producing the time lag in early stages of growth, since the single-crystal-ized AlN buffer layer is formed on silicon on sapphire, growth can be started and it has the operation which is further excellent in flat nature.

[0012]

[Example] Next, the example of this invention is explained. In addition, an example is one instantiation, it is the range which does not deviate from the pneumonia of this invention, and it cannot be overemphasized that various change or improvement can be performed.

[0013] (Example 1) Drawing 1 is drawing explaining the first example of this invention, and shows the cross section of a light emitting device. This light emitting device consists of an electrode 6 of the nitrated case 2 (a nitriding depth of 50Å) formed in the front face of the sapphire (0001) substrate 1, the AlN buffer layer 3 of 500Å of thickness, the Si dope n type low resistance GaN layer 4 of 5 micrometers of thickness, the GaN luminous layer 5 formed into the half-insulation by Zn doping of 0.5 micrometers of thickness, and a half-insulating layer, and an ohmic electrode 7 of a low resistive layer [type / n]. When negative voltage was applied to the electrode 6 for positive voltage at the electrode 7, the luminous layer 5 emitted light on the wavelength of 480nm. The maximum optical output was 0.8mW and the external quantum efficiency was 0.2%. At this example, although GaN was used as an n type low resistive layer and a half-insulating layer, luminescence wavelength can be changed in 300-800nm by replacing with this and using $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$).

[0014] (Example 2) Drawing 2 is drawing explaining the second example of this invention, and shows the cross section of a light emitting device. This light emitting device consists of an ohmic electrode 16 of the nitrated case 11 (a nitriding depth of 50Å) formed in the front face of the sapphire (0001) substrate 10, the AlN buffer layer 12 of 500Å of thickness, the Si dope n type InAlN clad layer 13 of 5 micrometers of thickness, the undoping InGaIn barrier layer 14 of 0.5 micrometers of thickness, the Mg dope p type InAlN clad layer 15 of 2 micrometers of thickness, and p type clad layer, and an ohmic electrode 17 of n type clad layer. The InAlN layer 13 and the InGaIn layer 14 which were shown here carried out grid adjustment mutually, and they chose composition so that 0.3eV or more of bandgap energy of a clad layer might become large compared with the bandgap energy of a barrier layer. Consequently, the refractive index of a clad layer becomes small about 10% compared with the refractive index of a

barrier layer. When negative voltage was applied to the electrode 16 for positive voltage at the electrode 17, the barrier layer 14 emitted light on the wavelength of 420nm. The maximum optical output was 13mW and the external quantum efficiency was 3%. [0015] this example -- as n type and p type clad layer -- InAlN -- moreover, although InGaN was used as a barrier layer, luminescence wavelength can be changed in 190-650nm by carrying out grid adjustment mutually and changing composition under the conditions that 0.3eV or more of bandgap energy of a clad layer becomes large compared with the bandgap energy of a barrier layer

[0016] Drawing 3 is an III group organic metal and NH₃ as material gas. About the case where it uses, an example of the growth equipment for enforcing the production method of the semiconductor light emitting device of this invention is shown. drawing -- setting -- 20 -- a sapphire (0001) substrate and 21 -- a carbon susceptor and 22 -- a quartz coil and 23 -- a RF induction coil and 24 -- a thermocouple and 25 -- an organic-metal gas introduction pipe and 26 -- NH₃ A gas introduction pipe and 27H₂ Gas and N₂ A gas introduction pipe and 28 show an exhaust port.

[0017] In order to produce the multilayer structure for the semiconductor light emitting devices of this invention with this equipment, the inside of the quartz coil 22 is first exhausted with evacuation equipment. Next, it is H₂ for 0.5-20l./in the quartz coil 22. After introducing gas, sapphire (0001) substrate 20 front face is defecated by energizing the RF induction coil 23 by heating the carbon susceptor 21 at 1000-1300 degrees C, and holding it for 1 to 60 minutes. Then, H₂ It is 0.5-20l.NH₃ for /about gas. From changing to gas and holding for 1 to 60 minutes, sapphire (0001) substrate 20 front face is formed into single crystal AlN. Next, the temperature of the carbon susceptor 21 is lowered to 500-1000 degrees C. It is the trimethylaluminum (TMAI) which set the temperature of a bubbler as 15-60 degrees C in this state H₂ for 1-1000 cc/Bubbling is carried out by gas (or N₂ or Ar gas), and it is H₂ for 0-20l./ From the post-introduction pipe 25 made to join gas (or N₂ or Ar gas), the quartz coil 22 is supplied and a single crystal or an amorphous AlN layer is deposited. The total gas ** in the quartz coil 22 under growth is adjusted to 40 - 1000Torr. Supply to the quartz coil 22 of TMAI is stopped in the place on which 10-2000A of AlN(s) was made to deposit, the carbon susceptor 21 is heated at 1000-1300 degrees C, and it is NH₃. The AlN film deposited by holding in atmosphere for 1 to 60 minutes is single-crystal-ized. Multilayer structures, such as a clad layer for light emitting devices and a barrier layer, are produced after this.

[0018] the above-mentioned example -- as an III group raw material and a nitrogen raw material -- TMAI and NH₃ although used -- this -- replacing with -- other III group raw materials, such as other III group organic metals, such as TEAl, or an III group halide ghost, and N₂ H₂ Even if it uses the nitrogen raw material of others, such as an organic amine, the effect of this appearance is acquired. In the above-mentioned example, although the field was used as a field direction (0001) of silicon on sapphire, even if it replaces with this and uses a field (0112), a field (0110), and a field (2110), the same effect is acquired.

[0019]

[Effect of the Invention] Growth can be started in the semiconductor light emitting device of this invention, without producing the time lag in early stages of growth as drawing 4 shows the sapphire front face which turned AlN by carrying out nitriding treatment beforehand, in order to carry out the low-temperature deposition of the AlN layer. For this reason, the thickness control of an AlN buffer layer can be performed with precisely sufficient repeatability. In advance of deposition of AlN, about a sapphire front face, AlN, since it was made to turn, this is for deposition to begin simultaneously with the attainment to the substrate front face of aluminum material gas. Moreover, in depositing AlN on a surface nitrated case, when becoming a continuation film by thinner thickness compared with the case where it deposits on unsettled silicon on sapphire directly, it has the advantage of excelling also in flat nature. Furthermore, since the nitrated case formed on silicon on sapphire has the effect which raises the crystallinity of the AlN buffer layer deposited on it, it also raises the property of the epitaxial film which grew on it. Moreover, since the AlN layer which carried out low-temperature deposition has the operation which carries out flattening of the irregularity of the atomic order produced on the sapphire front face by nitriding treatment, in case it grows epitaxially a direct III group nitride semiconductor thin film on a sapphire surface nitrated case, it can suppress the three-dimensions growth which poses a problem.

[0020] Consequently, according to this invention, an efficient and long lasting semiconductor light emitting device is producible with sufficient repeatability. Especially the thing for which the thickness-control nature in the initial stage of the AlN layer which the nitrated case formed on silicon on sapphire deposits on it, and its flat nature and crystallinity are raised is a completely new effect.

[Translation done.]

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

EFFECT OF THE INVENTION

[Effect of the Invention] Growth can be started in the semiconductor light emitting device of this invention, without producing the time lag in early stages of growth as drawing 4 shows the sapphire front face which turned AlN by carrying out nitriding treatment beforehand, in order to carry out the low-temperature deposition of the AlN layer. For this reason, the thickness control of an AlN buffer layer can be performed with precisely sufficient repeatability. In advance of deposition of AlN, about a sapphire front face, AlN, since it was made to turn, this is for deposition to begin simultaneously with the attainment to the substrate front face of aluminum material gas. Moreover, in depositing AlN on a surface nitrated case, when becoming a continuation film by thinner thickness compared with the case where it deposits on unsettled silicon on sapphire directly, it has the advantage of excelling also in flat nature. Furthermore, since the nitrated case formed on silicon on sapphire has the effect which raises the crystallinity of the AlN buffer layer deposited on it, it also raises the property of the epitaxial film which grew on it. Moreover, since the AlN layer which carried out low-temperature deposition has the operation which carries out flattening of the irregularity of the atomic order produced on the sapphire front face by nitriding treatment, in case it grows epitaxially a direct III group nitride semiconductor thin film on a sapphire surface nitrated case, it can suppress the three-dimensions growth which poses a problem.

[0020] Consequently, according to this invention, an efficient and long lasting semiconductor light emitting device is producible with sufficient repeatability. Especially the thing for which the thickness-control nature in the initial stage of the AlN layer which the nitrated case formed on silicon on sapphire deposits on it, and its flat nature and crystallinity are raised is a completely new effect.

[Translation done.]

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] It was made in order that this invention might solve the above-mentioned trouble, and the purpose is in offering the efficient and long lasting semiconductor light emitting device by quality improvement of an III group nitride semiconductor $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) epitaxial film, and offering the method of producing a light emitting device with sufficient repeatability.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, let this invention be the summary of invention of the semiconductor light emitting device characterized by including the nitrated case formed in the aforementioned silicon-on-sapphire front face, and the AlN buffer layer deposited on the aforementioned nitrated case in the semiconductor light emitting device containing at least one layer ($0 \leq x \leq 1$, $0 \leq x+y \leq 1$) of $\text{In}_{1-x-y}\text{Ga}_x\text{Al}_y\text{N}$ formed on silicon on sapphire. Furthermore, the 1st process which this invention heat-treats silicon on sapphire in nitrogen material gas atmosphere, and forms a substrate front face into single crystal AlN, The 2nd process which deposits polycrystal or an amorphous AlN buffer layer by the reaction with aluminum material gas on a nitrated case, It considers as the summary of invention of the production method of the semiconductor light emitting device characterized by including the 3rd process which anneals the aforementioned AlN buffer layer at an elevated temperature rather than the deposition temperature, and the 4th process which forms the luminous layer containing at least one layer of InGaAlN layers. If it puts in another way, the semiconductor light emitting device of this invention will be characterized [main] by including the AlN buffer layer deposited on the nitrated case formed in the silicon-on-sapphire front face, and this nitrated case. Moreover, the production method of the semiconductor light emitting device of this invention is characterized [main] by including the first process which carries out nitriding treatment of the silicon on sapphire in nitrogen material gas atmosphere, the second process which deposits an AlN buffer layer by the reaction of aluminum material gas and nitrogen material gas on this nitrated case, and the third process which anneals this AlN buffer layer at an elevated temperature rather than deposition temperature.

[0010] In the structure and the production method, the following points differ from the semiconductor light emitting device produced on sapphire through the conventional AlN layer. That is, the points containing the AlN buffer layer single-crystal-ized by annealing after low-temperature deposition in contact with the semiconductor light emitting device which produced the front face by nitriding treatment on the silicon on sapphire which turned single crystal AlN to the surface nitrated case differ. The single-crystal-ized point differs from the semiconductor light emitting device produced through the AlN buffer layer deposited at the elevated temperature more than the single crystal growth temperature of AlN on silicon on sapphire by performing deposition of the point which has deposited the AlN buffer layer through a sapphire surface nitrated case, and an AlN layer at the low temperature from which a flat AlN layer is obtained, and annealing at an elevated temperature from this after that. Moreover, the point which has deposited the AlN buffer layer through a sapphire surface nitrated case differs from the semiconductor light emitting device produced through the AlN buffer layer single-crystal-ized by annealing at an elevated temperature from this after carrying out low-temperature deposition.

[Translation done.]

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

OPERATION

[Function] In this invention, without producing the time lag in early stages of growth, since the single-crystal-ized AlN buffer layer is formed on silicon on sapphire, growth can be started and it has the operation which is further excellent in flat nature.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

EXAMPLE

[Example] Next, the example of this invention is explained. In addition, an example is one instantiation, it is the range which does not deviate from the pneumonia of this invention, and it cannot be overemphasized that various change or improvement can be performed.

[0013] (Example 1) Drawing 1 is drawing explaining the first example of this invention, and shows the cross section of a light emitting device. This light emitting device consists of an electrode 6 of the nitrated case 2 (a nitriding depth of 50Å) formed in the front face of the sapphire (0001) substrate 1, the AlN buffer layer 3 of 500Å of thickness, the Si dope n type low resistance GaN layer 4 of 5 micrometers of thickness, the GaN luminous layer 5 formed into the half-insulation by Zn doping of 0.5 micrometers of thickness, and a half-insulating layer, and an ohmic electrode 7 of a low resistive layer [type / n]. When negative voltage was applied to the electrode 6 for positive voltage at the electrode 7, the luminous layer 5 emitted light on the wavelength of 480nm. The maximum optical output was 0.8mW and the external quantum efficiency was 0.2%. At this example, although GaN was used as an n type low resistive layer and a half-insulating layer, luminescence wavelength can be changed in 300-800nm by replacing with this and using In_{1-x}Al_xN (0 ≤ x ≤ 1, 0 ≤ x+y ≤ 1).

[0014] (Example 2) Drawing 2 is drawing explaining the second example of this invention, and shows the cross section of a light emitting device. This light emitting device consists of an ohmic electrode 16 of the nitrated case 11 (a nitriding depth of 50Å) formed in the front face of the sapphire (0001) substrate 10, the AlN buffer layer 12 of 500Å of thickness, the Si dope n type InAlN clad layer 13 of 5 micrometers of thickness, the undoping InGa_{0.5}N barrier layer 14 of 0.5 micrometers of thickness, the Mg dope p type InAlN clad layer 15 of 2 micrometers of thickness, and p type clad layer, and an ohmic electrode 17 of n type clad layer. The InAlN layer 13 and the InGa_{0.5}N layer 14 which were shown here carried out grid adjustment mutually, and they chose composition so that 0.3eV or more of bandgap energy of a clad layer might become large compared with the bandgap energy of a barrier layer. Consequently, the refractive index of a clad layer becomes small about 10% compared with the refractive index of a barrier layer. When negative voltage was applied to the electrode 16 for positive voltage at the electrode 17, the barrier layer 14 emitted light on the wavelength of 420nm. The maximum optical output was 13mW and the external quantum efficiency was 3%.

[0015] this example -- as n type and p type clad layer -- InAlN -- moreover, although InGa_{0.5}N was used as a barrier layer, luminescence wavelength can be changed in 190-650nm by carrying out grid adjustment mutually and changing composition under the conditions that 0.3eV or more of bandgap energy of a clad layer becomes large compared with the bandgap energy of a barrier layer

[0016] Drawing 3 is an III group organic metal and NH₃ as material gas. About the case where it uses, an example of the growth equipment for enforcing the production method of the semiconductor light emitting device of this invention is shown. drawing -- setting -- 20 -- a sapphire (0001) substrate and 21 -- a carbon susceptor and 22 -- a quartz coil and 23 -- a RF induction coil and 24 -- a thermocouple and 25 -- an organic-metal gas introduction pipe and 26 -- NH₃ A gas introduction pipe and 27 H₂ Gas and N₂ A gas introduction pipe and 28 show an exhaust port.

[0017] In order to produce the multilayer structure for the semiconductor light emitting devices of this invention with this equipment, the inside of the quartz coil 22 is first exhausted with evacuation equipment. Next, it is H₂ for 0.5-20l./in the quartz coil 22. After introducing gas, sapphire (0001) substrate 20 front face is defecated by energizing the RF induction coil 23 by heating the carbon susceptor 21 at 1000-1300 degrees C, and holding it for 1 to 60 minutes. Then, H₂ It is 0.5-20l.NH₃ for /about gas. From changing to gas and holding for 1 to 60 minutes, sapphire (0001) substrate 20 front face is formed into single crystal AlN. Next, the temperature of the carbon susceptor 21 is lowered to 500-1000 degrees C. It is the trimethylaluminum (TMAI) which set the temperature of a bubbler as 15-60 degrees C in this state H₂ for 1-1000 cc/Bubbling is carried out by gas (or N₂ or Ar gas), and it is H₂ for 0-20l./ From the post-introduction pipe 25 made to join gas (or N₂ or Ar gas), the quartz coil 22 is supplied and a single crystal or an amorphous AlN layer is deposited. The total gas ** in the quartz coil 22 under growth is adjusted to 40 - 1000Torr. Supply to the quartz coil 22 of TMAI is stopped in the place on which 10-2000Å of AlN(s) was made to deposit, the carbon susceptor 21 is heated at 1000-1300 degrees C, and it is NH₃. The AlN film deposited by holding in atmosphere for 1 to 60 minutes is single-crystal-ized. Multilayer structures, such as a clad layer for light emitting devices and a barrier layer, are produced after this.

[0018] the above-mentioned example -- as an III group raw material and a nitrogen raw material -- TMAI and NH₃ although used -- this -- replacing with -- other III group raw materials, such as other III group organic metals, such as TEAl, or an III group halide ghost, and N₂ H₂ Even if it uses the nitrogen raw material of others, such as an organic amine, the effect of this appearance is acquired. In the above-mentioned example, although the field was used as a field direction (0001) of silicon on sapphire, even if

it replaces with this and uses a field (0112), a field (0110), and a field (2110), the same effect is acquired.

[Translation done.]

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] One example of the semiconductor light emitting device of this invention.

[Drawing 2] Other examples of the semiconductor light emitting device of this invention.

[Drawing 3] The epitaxial growth system of the compound semiconductor thin film used when producing the semiconductor light emitting device of this invention.

[Drawing 4] The growth time dependency of the growth thickness in the AlN growth initial stage on the silicon on sapphire which carried out nitriding treatment is shown.

[Drawing 5] The growth time dependency of the growth thickness in the AlN growth initial stage on unsettled silicon on sapphire is shown.

[Description of Notations]

- 1 Sapphire (0001) Substrate
- 2 Sapphire Surface Nitrated Case
- 3 AlN Buffer Layer
- 4 Si Dope N Type Low Resistance GaN Layer
- 5 Zn Dope Half Insulation GaN Luminous Layer
- 6 Electrode of Half-Insulating Layer
- 7 Ohmic Electrode of Low Resistive Layer [Type / N]
- 10 Sapphire (0001) Substrate
- 11 Sapphire Surface Nitrated Case
- 12 AlN Buffer Layer
- 13 Si Dope N Type InAlN Clad Layer
- 14 Undoping InGaN Barrier Layer
- 15 Mg Dope P Type InAlN Clad Layer
- 16 Ohmic Electrode of P Type Clad Layer
- 17 Ohmic Electrode of N Type Clad Layer
- 20 Sapphire (0001) Substrate
- 21 Carbon Susceptor
- 22 Quartz Coil
- 23 RF Induction Coil
- 24 Thermocouple
- 25 Organic-Metal Gas Introduction Pipe
- 26 NH₃ Gas Introduction Pipe
- 27 H₂ Gas and N₂ Gas Introduction Pipe
- 28 Exhaust Port

[Translation done.]

*** NOTICES ***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

TECHNICAL FIELD

[Industrial Application] this invention relates to the semiconductor light emitting device which is ultraviolet and emits light from it being visible (infrared), and its production method.

[Translation done.]

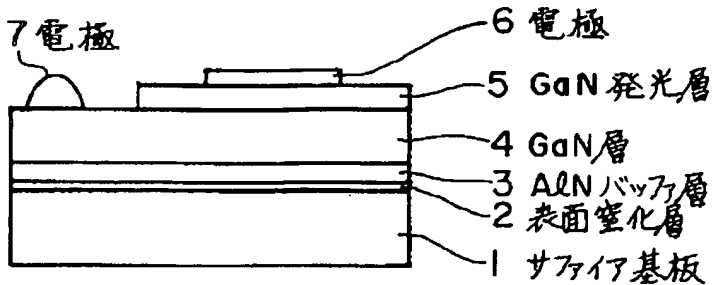
* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

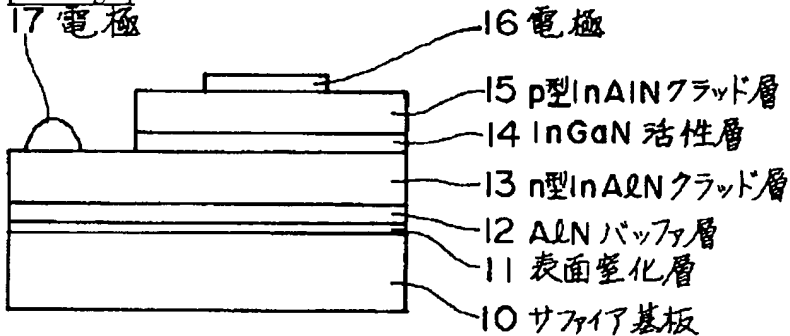
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

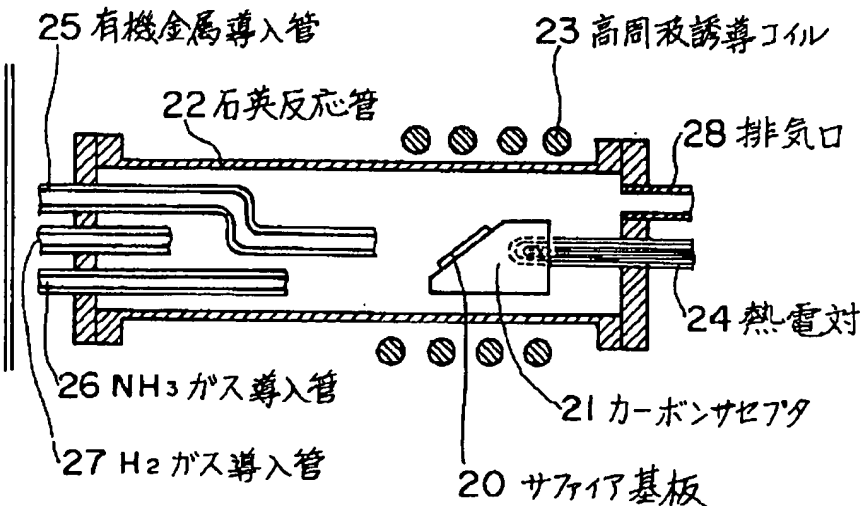
[Drawing 1]



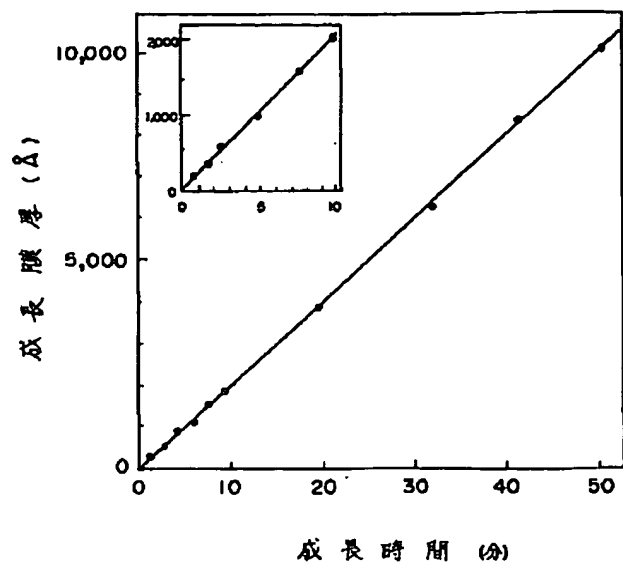
[Drawing 2]



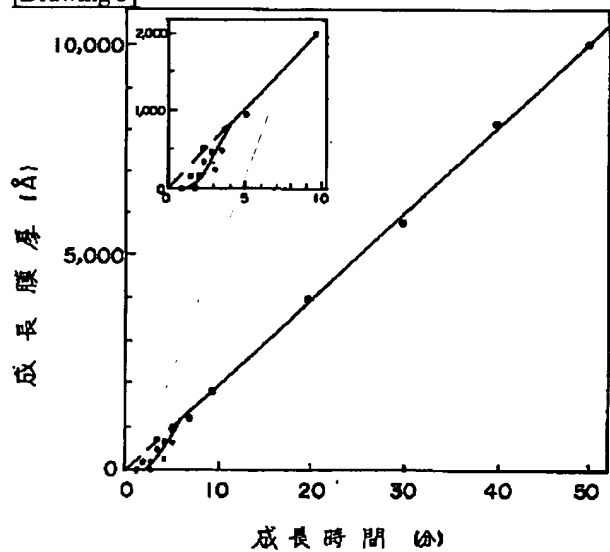
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Translation done.]